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LOGAN WALLER PAGE, Director.

BITUMENS AND THEIR ESSENTIAL CONSTITUENTS FOR ROAD CONSTRUCTION AND MAINTENANCE.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Public Roads,
Washington, D. C., December 5, 1910.

Sir: I have the honor to transmit herewith the manuscript of a circular by Mr. Prévost Hubbard, chemist in this office, entitled "Bitumens and Their Essential Constituents for Road Construction and Maintenance." This publication presents in condensed form a description and discussion of various bituminous materials at present in use in road construction and maintenance. It should be of great service in clearing up a very general misunderstanding concerning the actual and comparative value of bituminous road materials, and also the meaning of certain terms. I respectfully request that it be issued as Circular 93 of this office. In view of the newness of the subject and lack of complete data, some of the statements made may in the future require modification. This circular will therefore be revised from time to time in order to keep it abreast with the latest information obtainable.

Respectfully,

Logan Waller Page,
Director.

Hon. James Wilson,
Secretary of Agriculture.

BITUMENS AND THEIR ESSENTIAL CONSTITUENTS FOR ROAD CONSTRUCTION AND MAINTENANCE.

So much confusion exists among road engineers and others interested in bituminous road binders concerning the meaning of certain terms as applied to these materials that it has seemed advisable to present in brief form the definitions of such terms as at present used by the United States Office of Public Roads. It should be understood, however, that these definitions are at present more or less arbitrary, owing to wide differences of opinion held by those who are considered authorities on the subject of bitumens. Notwithstanding these facts, it is hoped that this circular will furnish highway engineers and other interested persons with a foundation for acquiring and systematically classifying further information along the lines herein indicated. To aid them in this matter a brief discussion of the value of the various materials used in road construction has been given in addition to the definitions.

Acid Sludge.—A mixture of sulphonated hydrocarbons resulting from the treatment of bitumens with sulphuric acid; usually a waste or by-product obtained in this manner from the purification of tar and oil distillates. When sufficiently concentrated these sulphonated products become viscous and gummy. They are readily attacked by water and are therefore unsuitable for use as enduring road binders.

Anthracene.—A waxy crystalline hydrocarbon having the chemical formula $C_{14}H_{10}$, found in tars, principally coal tars which have been produced at high temperatures. Anthracene is believed to be of no practical value in road binders.

Artificial Asphalt.—See Asphalts and Oil Asphalts.

Artificial Bitumens.—Hydrocarbon distillates and residues produced by the partial or fractional distillation of bitumens, and hydrocarbon distillates produced by the destructive distillation of bitumens, pyrobitumens, and other organic materials, such as wood, bone, etc. Native bitumens which have been treated merely for the removal of water and extraneous organic and inorganic materials should not be classed as artificial products, but as refined native bitumens.

Asphalts.—Solid or semisolid native bitumens, consisting of a mixture of hydrocarbons of complex structure, largely cyclic and bridge compounds, together with a small proportion of their sulphur and nitrogen derivatives, but free from any appreciable amount of solid

paraffins, melting[1] upon the application of heat and evidently produced by nature from petroleums containing little or no solid paraffins. Solid or semisolid residues produced from probably similar oils by artificial processes are sometimes called asphalts, but should more properly be termed oil asphalts. The more common types of native asphalts are known by the name of the locality in which they occur, such as Trinidad, Bermudez, Maracaibo, Cuban, California, etc. Native asphalts with few exceptions contain water, extraneous organic or vegetable matter, and inorganic matter, such as clay, sand, etc. A large proportion of these impurities is removed by a rough refining process without otherwise changing the character of the asphalt.

Native asphalts are usually too hard to be used as road binders without first fluxing them with a heavy petroleum residuum and thus producing an asphaltic cement. Artificial asphalts are, as a rule, brought to suitable consistency during the process of manufacture.

Asphaltenes.—A term commonly applied to those hydrocarbons in petroleums, petroleum products, malthas, asphaltic cements, and solid native bitumens which are soluble in carbon bisulphide but insoluble in paraffin naphtha. As a rule paraffin naphthas of different specific gravities and boiling points dissolve different amounts of hydrocarbons in a given bitumen, and the heavier the naphtha and the higher its boiling point the greater is its solvent action. It is evident, therefore, that the percentage of asphaltenes will vary with the gravity and boiling point of the naphtha, and for this reason it would seem well to substitute for the term asphaltenes, "bitumen insoluble in paraffin naphtha," with a statement of the gravity of the naphtha used and the temperatures between which it boils. The presence of naphtha insoluble hydrocarbons is supposed to give body to the product in which they occur and to be accountable to a great extent for its binding value. They show no binding value, since many of them are hard and brittle, but they produce adhesive mixtures when fluxed with certain heavy oils. As a rule, for a given type of bitumen hardness increases with the percentage of bitumen insoluble in a given naphtha. The so-called asphaltenes are not found to any extent in native bitumens with a paraffin base, but occur principally in asphalts, malthas, asphaltic petroleums, and in blown petroleum residues. They vary chemically and physically with the product in which they occur, and, therefore, do not represent definite chemical compounds.

Asphaltic Petroleums.—Asphaltic petroleums, or asphaltic oils, are petroleums containing an asphaltic base—i. e., they are capable of producing residues very similar to native asphalts if evaporated or distilled down to the consistency of such asphalts. They contain little

[1] See Bitumens.

or no solid paraffins and are thus differentiated from paraffin petroleums. Native asphalts are probably produced from such oils by natural processes.

Asphaltic Cement.—The term asphaltic cement was originally applied to a product obtained by fluxing an asphalt with a sufficient quantity of heavy residual oil or flux to produce a binder of suitable consistency for paving purposes. In its broadest sense it may be applied to all semisolid bitumens of an asphaltic nature which are of suitable consistency for use as binders in street or road construction, whether prepared by fluxing a solid native or artificial bitumen or by reducing an asphaltic or semiasphaltic petroleum by distillation or other process.

Baumé Gravity.—An arbitrary scale of specific gravity or density of liquids, usually expressed as degrees Baumé or ° B. This scale is commonly used in connection with oil products. For liquids lighter than water the scale begins at 10° B., which represents the specific gravity of water, or 1.0000. As the Baumé degrees increase the specific gravity decreases. The following formulæ are used in converting Baumé degrees for liquids lighter than water into direct specific gravity and vice versa:

$$\text{Sp. gr.} = \frac{140}{130 + {}^\circ \text{B}} \text{ at } 17.5^\circ \text{ C.}$$

$${}^\circ \text{B} = \frac{140}{\text{Sp. gr.}} - 130 \text{ at } 17.5^\circ \text{ C.}$$

For liquids heavier than water the scale begins at 0° B., which represents the specific gravity of water, or 1.0000. In this scale the degrees Baumé increase with the specific gravity. The following formulæ are used in converting Baumé degrees for liquids heavier than water into direct specific gravity and vice versa:

$$\text{Sp. gr.} = \frac{145}{145 - {}^\circ \text{B}} \text{ at } 15.5^\circ \text{ C.}$$

$${}^\circ \text{B} = 145 - \frac{145}{\text{Sp. gr.}} \text{ at } 15.5^\circ \text{ C.}$$

Benzol.—A volatile colorless fluid hydrocarbon of characteristic odor having the chemical formula C_6H_6. It occurs mainly in crude coal tars and water-gas tars, and boils at 80.4° C., so that it is removed in the first fraction when these tars are subjected to the process of distillation. Benzol is an active solvent for most bitumens. It is sometimes called benzene, but should not be confused with benzine, which is the term applied to the lighter and more volatile fractions of petroleum.

Bitumen.—Bitumens are mixtures of native or pyrogenetic hydrocarbons and their derivatives, which may be gases, liquids, viscous liquids, or solids. If solids, they melt more or less readily upon the application of heat and are soluble in carbon bisulphide, chloroform, and similar solvents. They may be divided into two main classes—(1) native bitumens and (2) artificial bitumens. Bitumens, being mixtures of hydrocarbons, can have no melting point, although this term is often used to denote the temperature at which they soften sufficiently to flow.

Bituminous.—A term applied not only to materials or objects which contain bitumen, such as bituminous rock, bituminous macadam, etc., but also to certain pyro-bitumens, such as bituminous coal, which give rise to the formation of bitumens upon being subjected to the process of destructive distillation.

Blown petroleum.—Blown petroleums, which are often called blown oils, are petroleum residuums through which a jet of air has been passed during or just after distillation. The blowing process causes certain chemical reactions of a complicated nature to take place and results in thickening or increasing the consistency of the oil to an extent depending upon its temperature and the amount of blowing which it receives. Semisolid and solid products are thus often formed from fluid residuums. If the oil is asphaltic or semiasphaltic in nature, asphaltic cements may be produced in this manner. Blown oils are characteristically short or nonductile when semisolid, although they may possess considerable binding value if not originally of a paraffin nature. Blowing an oil usually increases its percentage of hydrocarbons insoluble in any given paraffin naphtha.

Carbenes.—A term commonly applied to those hydrocarbons in petroleum, petroleum products, malthas, asphaltic cements, and solid native bitumens which are soluble in carbon bisulphide but insoluble in carbon tetrachloride. The presence of an appreciable amount of these hydrocarbons indicates that the material in which they occur has been subjected to unnecessarily high temperatures. Cracked oil residuums show an increase in carbenes in proportion to the extent of cracking and the formation of these products is evidently a near step to coking. But little is known of their effect upon the value of a bitumen for road construction, but they are generally looked upon with suspicion and, in certain specifications for asphaltic cements, their presence has been limited to a low percentage.

Carbon Bisulphide.—This substance, sometimes called carbon disulphide, is a volatile and extremely inflammable compound of carbon and sulphur, boiling at 47° C. and having the chemical formula CS_2. Pure carbon bisulphide is a colorless mobile liquid having an ethereal odor. It is one of the most active solvents for bitumens

and is commonly employed for this purpose in the determination of total bitumen.

Carbon Tetrachloride.—A volatile noninflammable compound of carbon and chlorine, boiling at 76° C. It is a colorless mobile liquid with an odor similar to that of chloroform, to which it is closely related, and has the chemical formula CCl_4. It is an excellent solvent for bitumens, but is not usually as powerful as carbon bisulphide. It is employed in bitumen analysis for the determination of carbenes or hydrocarbons soluble in carbon bisulphide but insoluble in carbon tetrachloride.

Coal Tar.—A mixture of hydrocarbon distillates, mostly unsaturated ring compounds, produced in the destructive distillation of coal. Crude coal tar is a black, more or less viscid fluid having a gassy odor and varying in specific gravity from 1.10 to 1.25 and sometimes higher. It always contains a certain amount of ammoniacal water which makes it unsuitable for use as a road binder. When reduced to proper consistency by distillation, coal tar makes an excellent bituminous road binder, providing it does not carry too high percentages of free carbon and naphthalene. The composition of coal tar varies according to the coal from which it is produced and the method of distillation. Tars produced at high temperatures contain a large amount of free carbon and usually run high in naphthalene, while those produced at low temperatures carry less free carbon and as a rule less naphthalene. Low temperature coal tars are therefore most suitable for the preparation of road binders.[1]

Coke-Oven Tar.—Coal tar produced from by-product coke ovens in the manufacture of coke from bituminous coal. This process of coke manufacture is essentially the same as that of coal gas. Larger charges of coal are, however, carbonized in the former, and as a rule carbonization is conducted at a lower temperature than in the manufacture of coal gas. The resulting tar therefore contains a smaller amount of free carbon, averaging from 3 to 10 per cent, and is better suited for the preparation of road binders than most gas-house coal tars.

Cracked Oil.—The term cracked oil, as applied to road binders, refers to petroleum residuums which have been overheated in the process of manufacture. Overheating causes a breaking down of certain constituents of the oil, which results first in the formation of carbenes and later of coke or free carbon. Badly cracked residuums are believed to be inferior road binders.

Cracking.—The process of breaking down a hydrocarbon molecule by the application of heat. This may result either in the formation of other hydrocarbon molecules, at least one of which is unsaturated

[1] See Refined tar.

and shows a higher ratio of carbon to hydrogen than the original molecule, or else in the disruption of the molecule into its elements, hydrogen and carbon. In the latter case the process is said to be destructive. The more volatile and chemically stable hydrocarbons can be cracked only at temperatures above their boiling points. In the distillation of oils this is accomplished by causing condensation to take place in the still and allowing the condensed oils to fall back into the residue, the temperature of which is considerably higher than their boiling points. In carbureted water-gas manufacture, oils are cracked by vaporizing them at a much higher temperature than their boiling points. The heavier oils will, however, crack at temperatures below their normal boiling points, and this is particularly true of asphaltic oils, which have to be distilled very carefully, sometimes under reduced pressure, in order to produce residuums which are not cracked.

Cut-Back Products.—Petroleum or tar residuums which are cut back, or fluxed, to the desired consistency with a distillate. Volatile distillates are employed for this purpose in the preparation of road binders, when it is desired to have the binder increase in consistency or become harder after application. In such cases a residuum of proper consistency for a road binder is cut back merely for the purpose of facilitating application.

Dead Oils.—Heavy oils distilled from tars at between 170° and 270° C. with a density greater than water. These oils, if free from naphthalene, serve as an excellent flux in the preparation of cut-back road binders from tar pitches, which are too brittle for this purpose.

Destructive Distillation.—A process of distilling organic materials in which the identity of the material distilled is destroyed, resulting in the formation of tarry distillates and a coke residue.

Dehydrated Tar.—Crude tar from which all water has been removed by distillation and mechanical contrivances known as separators.

Emulsions.—Oily substances made miscible with water through the action of a saponifying agent or soap. Petroleums and tars may be emulsified by this means and such emulsions, if properly prepared from good materials, are often serviceable in the treatment of roads. The majority of road emulsions can be considered only as dust palliatives and temporary binders.

Fixed Carbon.—The residual coke obtained upon burning hydrocarbon products in a covered vessel in the absence of free oxygen, according to an arbitrary method. As applied to bituminous road materials, the determination of fixed carbon would seem to be of value in connection with petroleum and asphaltic products only. Paraffin hydrocarbons produce little or no fixed carbon, while those of asphaltic character show a very considerable amount, depending upon the percentage of asphaltic compounds present and the consistency of

the material. The fixed carbon determination therefore indicates the mechanical stability and body of such materials. It is not, however, an extremely accurate determination and should not be too strongly relied upon. Since fixed carbon is a product formed by ignition, it should not be confused with free carbon, which is a material already existing in suspension. The presence of any considerable quantity of free carbon vitiates a fixed carbon determination.

Flux.—As applied to road binders, this term covers fluid oils and tars which are incorporated with asphalts and semisolid or solid oil and tar residuums for the purpose of reducing their consistency. Fluid petroleum residuums are commonly employed as fluxes in the preparation of asphaltic cements. A good flux produces an absolutely homogeneous bituminous mixture. Both petroleum and tar fluxes will produce such mixtures with native and artificial asphalts, but most fluid petroleum products will not flux tar pitches satisfactorily.

Free Carbon.—Organic matter in tars which is insoluble in carbon bisulphide. This material is an inert black powder, which is held in suspension by the tar proper, and probably consists, not only of free carbon, but also of hydrocarbons extremely rich in carbon. It has no binding value and serves no useful purpose in a road binder other than to act as a filler. It gives the tar in which it occurs a false consistency, reduces the binding capacity of the tar, and probably interferes with its penetration into and absorption by the road stone or road surface. The maximum allowable limit of free carbon in road binders would seem to be about 20 per cent.

Gas-House Coal Tar.[1]—Coal tar produced as a by-product in the manufacture of illuminating gas from coal. The modern gas-house coal tar is usually produced at high temperatures and therefore carries a percentage of free carbon varying from 20 to 30 per cent and higher. Unless it is produced at low or medium temperatures and contains less than 20 per cent free carbon, it is not well suited for the preparation of a dust palliative or road binder by direct distillation. High-carbon tars may, however, be combined with low-carbon tars in such proportion as to produce, when distilled to proper consistency, excellent road binders carrying less than 20 per cent free carbon.

Gilsonite.—A very pure solid native bitumen possessing many of the characteristics of asphalt. It differs from most of the native asphalts by being more brittle, having a higher melting or softening point, and being much less soluble in 86° B. paraffin naphtha. When fluxed with certain petroleum residuums it produces excellent asphaltic cements. In the preparation of road binders it is extensively used for the purpose of reinforcing blown oils, with which it combines to

[1] See Coal tar.

form rubbery semisolid mixtures. Such preparations are sometimes termed mineral rubber.

Grahamite.—A pure solid native bitumen, black and brittle, which does not melt readily, but intumesces at high temperatures. It is differentiated from gilsonite and the native asphalts by the fact that it is almost insoluble in paraffin naphtha. It has been produced at high temperatures, as evidenced by the percentage of carbenes which it contains, and some varieties closely approach the pyrobitumens in characteristics. It has been used to some extent in the preparation of asphaltic cements, but up to the present has been little used in the manufacture of road binders.

High-Carbon Tars.—Tars containing a high percentage of free carbon—above 20 per cent. High-carbon tars are produced at high temperatures during the destructive distillation of coal and are of inferior quality for use as dust palliatives and road binders.

Hydrocarbons.—Chemical compounds composed of the elements hydrogen and carbon. There is practically an unlimited number of such compounds, which vary greatly in physical and chemical characteristics. Complex mixtures of hydrocarbons constitute by far the greater proportion of all bitumens.

Low-Carbon Tars.—Tars containing a low percentage of free carbon—less than 10 per cent. Low-carbon tars are produced at comparatively low temperatures during the destructive distillation of coal, and also by cracking oil vapors during the manufacture of carbureted water gas. As a rule they are more suitable than high-carbon tars for use as dust palliatives and road binders, or for the preparation of such substances.

Malthas.—Malthas are very viscous semiasphaltic or asphaltic native bitumens holding an intermediate position between the petroleums of an asphaltic nature and the native asphalts. As a rule they possess excellent binding properties. They constitute the binding material of many bituminous rocks or rock asphalts, and in this capacity often serve as valuable road binders. Many malthas have a tendency to harden rapidly when exposed to atmospheric conditions, and this property, while accountable for an increase in binding value, makes them unsuitable for use as a flux in the preparation of asphaltic cements.

Malthenes.—A term commonly applied to those hydrocarbons in petroleum, petroleum products, malthas, asphaltic cements, and solid native bitumens soluble in both carbon bisulphide and paraffin naphtha, but not readily volatile at temperatures lower than 163° C. (325° F.). This class of hydrocarbons serves as a valuable permanent fluxing medium for the so-called asphaltenes or naphtha insoluble bitumen in asphaltic cements, giving the cement any desired degree of softness when present in the right amount. It is evident, therefore, that the consistency of asphaltic bitumens, and particularly stable

asphaltic cements, is largely dependent upon the relative proportion of naphtha soluble and naphtha insoluble hydrocarbons. The same objection to the use of the term "asphaltenes"[1] applies to the use of the term "malthenes."

Mineral Rubber.—A term sometimes applied to artificial bitumens of rubbery consistency, usually composed of a mixture of gilsonite and blown petroleum residuum.

Naphthas.—Mixtures of hydrocarbons of low boiling points occurring rarely in nature, commonly obtained from the fractional distillation of certain bitumens. When this term is applied to low-boiling coal-tar distillates, it is usually prefixed by the words "coal tar." The word "naphtha" by itself is generally applied to low-boiling petroleum products. Different grades of naphtha are differentiated not only by their boiling points but also by their specific gravities, which are commonly given in Baumé degrees. Those of very low boiling points and specific gravities are called petrolic ethers. Naphthas vary not only in the two properties above mentioned but also with the type of petroleum from which they are obtained. Those derived from paraffin petroleums are quite different chemically from naphthas obtained from asphaltic petroleums. The former are much less powerful solvents for asphaltic substances than the latter. Paraffin naphtha is used as a solvent for the separation of certain classes of hydrocarbons in asphaltic substances.

Naphthalene.—A solid crystalline highly volatile hydrocarbon occurring principally in coal tars and having the chemical formula $C_{10}H_8$. Its presence in excessive quantities in road tars is believed to be detrimental, as it possesses no binding value and gradually volatilizes from the tar, leaving it hard and brittle.

Native Bitumens.—Mixtures of hydrocarbons occurring in nature, which may be gases, liquids, viscous liquids, or solids, but if solid melting[2] more or less readily upon the application of heat and dissolving in carbon bisulphide, chloroform, and similar solvents. The native bitumens that are of use as road materials are petroleums, malthas, asphalts, and other solid products such as gilsonite and grahamite. Native bitumens often contain impurities such as water, inorganic matter in the form of clay, silt, sand, etc., and extraneous organic or vegetable matter.

Oil Asphalts.—Artificial oil pitches or asphaltic cements produced as a residuum in the distillation of semiasphaltic and asphaltic petroleum. Many of these products are blown and are therefore known as blown oils.

Oil Pitches.—More or less hard oil asphalts.

Oil Tars.[3]—Mixtures of hydrocarbon distillates, mostly unsaturated ring compounds, produced in the cracking of oil vapors at high tem-

[1] See Asphaltenes. [2] See Bitumens. [3] See Water-gas tar.

peratures. Oil tars are usually by-products of the manufacture of oil gas or carbureted water gas.

Paraffin Naphthas.—Naphthas consisting of a mixture of light volatile hydrocarbons of the paraffin series, ordinarily obtained as light distillates of paraffin petroleum.

Paraffin Petroleum.—Petroleum the base of which is composed principally of the paraffin or open-chain series of hydrocarbons; it is thus differentiated from asphaltic petroleums which are composed largely of cyclic or ring hydrocarbons. Paraffin petroleums and the unaltered residues produced by their distillation are of inferior value as dust palliatives and road binders.

Paraffin Scale.—Solid paraffins recovered by distillation and precipitation of the distillates of petroleum and similar materials. The percentage of paraffine in bitumen is usually determined in this manner.

Paraffine.—The term paraffine covers a number of greasy crystalline hydrocarbons of the paraffin series occurring as dissolved wax in certain classes of petroleum. When these products are recovered from petroleum, they constitute the commercial product paraffine. Paraffine is believed to be detrimental to road binders in which it occurs, and it is certain that its presence in excessive amounts indicates inferiority in the binding value of the material. It is probable, however, that heavy liquid hydrocarbons of the same chemical series as solid paraffine exert a much more injurious effect.

Petrolenes.—An ambiguous term sometimes applied to those hydrocarbons described under malthenes, which are soluble in carbon bisulphide but insoluble in paraffin naphtha, and sometimes to hydrocarbons in petroleum and petroleum products volatile at or below 163° C. (325° F.). Owing to misconceptions which may occur, it would seem advisable to eliminate the use of this term.

Petroleums.—Petroleums, or mineral oils, are fluid native bitumens of variable composition, depending largely upon the locality in which they occur. There are three general types of petroleum found in the United States: (1) Paraffin petroleums, (2) semiasphaltic petroleums, and (3) asphaltic petroleums. Paraffin petroleums occur mainly in the eastern part of the United States and are typified by the Pennsylvania oils. The semiasphaltic variety occurs in the southern and middle western parts of the United States. Texas is one of the main sources of this type. Asphaltic petroleums occur in the western part of the United States, particularly in California. Petroleums, if of semiasphaltic or asphaltic character, may make excellent dust palliatives and road binders when properly treated.

Petrolic Ethers.—Very light volatile naphthas obtained from petroleum.

Pitches.—Semisolid or solid residues produced in the evaporation or distillation of bitumens. This word is often prefixed by the name

of the material from which it is derived, such as oil pitch, coal-tar pitch, etc. As a rule the term pitch is confined to the harder residuums, most of which are too hard for use as road binders unless fluxed with a more fluid product.

Pyrobitumens.—Mineral organic substances which are but slightly acted upon by the solvents for the bitumens, but which, upon being subjected to destructive distillation, give rise to the formation of bitumens. Pyrobitumens are derived in nature both from bitumens and direct metamorphosis of vegetable matter. Among the former class may be mentioned Albertite and Wurtzilite, and among the latter, peat, lignite, and bituminous coal.

Pyrogenetic.—Originating from the action of heat. Coal tar is thus a pyrogenetic bitumen.

Reduced Petroleums or Reduced Oils.—Residual oils produced from crude petroleum by the removal of water and the more volatile oil constituents, without chemically altering the base by cracking or other means. These residues are often made by distilling the crude oil under reduced pressure. Such products are of little value for road treatment unless formed from semiasphaltic or asphaltic oils.

Refined Tar.—A more or less viscous tar which is produced by evaporation or distillation of crude tar until the residue is of the desired consistency. This term also includes blown tars and cut-back products produced by fluxing tar pitches with volatile or non-volatile distillates. Refined tars are of value both as dust palliatives and as road binders in the treatment of macadam roads. Their binding value is proportional to their hardness within certain limits.

Residual Petroleums or Residual Oils.—Heavy viscous residues produced by the evaporation or distillation of crude petroleum until at least all of the burning oils have been removed and often some of the heavier distillates as well. Residual oils grade into the artificial asphalts and oil pitches as their hardness and viscosity increase. The more fluid products, if obtained from semiasphaltic or asphaltic petroleums, serve as excellent dust palliatives and semipermanent road binders for the surface treatment of roads. The more viscous products are often suitable for the surface treatment of roads if applied hot, but are seldom of value in road construction unless produced from semiasphaltic or asphaltic oils.

Residual Tars.—Heavy viscous residues produced by the evaporation or distillation of crude tar until all of the light oils have been removed. Residual tars grade into the tar pitches as their hardness and viscosity increase. If they do not contain an excess of free carbon, they are as a rule well adapted for use as binders in the construction of macadam roads.

Rock Asphalt or Bituminous Rock.—A term applied to a great variety of sandstones and limestones more or less impregnated with maltha.

Deposits of such material are widely distributed over the United States and vary from rock which is friable and wholly dependent upon the bitumen to hold the mineral fragments together to solid rock having merely its interstices filled with bitumen. The former type is of value for use as a surface binder in the construction of roads when the maltha shows good binding value and amounts to not less than 6 per cent of the weight of rock asphalt.

Semiasphaltic Petroleums.—Semiasphaltic petroleums or semiasphaltic oils are petroleums containing a semiasphaltic base, i. e., petroleums whose residues produced by evaporation or distillation, while composed mainly of asphaltic hydrocarbons, contain also a certain percentage of paraffin wax. They thus show a mixed base. If their percentage of heavy paraffin hydrocarbons is not excessive, they may be made to produce good dust preventives and road binders.

Short.—A term applied to bituminous materials which are nonductile.

Tar Pitches.—Semisolid or solid residual tars. Owing to the general brittleness of tar pitches, only the softer varieties are of value in their natural condition as road binders. The harder pitches may, however, be used for this purpose if fluxed to suitable consistency with heavy or dead oil distillates of tar.

Tars.—Tars are artificial or pyrogenetic bitumens produced as distillates by the destructive distillation of bitumens, pyrobitumens, and other organic material.

Water-Gas Tars.—Mixtures of hydrocarbon distillates, mostly unsaturated ring compounds, produced by cracking oil vapors at high temperatures in the manufacture of carbureted water gas. Crude water-gas tar is a thin, oily liquid having a specific gravity lying usually between 1 and 1.10. As a rule it contains a considerable quantity of water, which is, however, largely removed by mechanical devices before the tar is placed upon the market. This water is not ammoniacal, as in the case of crude coal tars. The composition of water-gas tar varies with the character of the oil which is carbureted and with varying conditions attending the carbureting process. It always shows a low percentage of free carbon, usually less than 2 per cent, and contains little or no naphthalene unless previously used for scrubbing coal gas. Crude water-gas tar has practically no binding value and is serviceable only as a dust palliative in the surface treatment of roads. When reduced to proper consistency by distillation, however, it shows certain desirable properties for use as a road binder both for surface treatment and macadam construction. Water-gas tar may also be used in the preparation of road binders from high-carbon coal tars. When this is done, the two crude tars are mixed in such proportion that when distilled to the desired consistency the mixture will contain less than the maximum limit of free carbon allowable.

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